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NORTHERN FOREST COMMUNITIES

Community Description

Wisconsin's northern forest communities are found north of the Tension zone, where they encompass an area of approximately 18.7 million acres. Vegetative cover exhibits a major change along the Tension Zone, as noted by one of Wisconsin's eminent community ecologists, John Curtis (1959) (see Figure 1). Before Euro-American settlement, this was the area where the prairies and oak savannas of the south transitioned into the mixed deciduous-coniferous forests of the north. Today, vegetation still changes along the Zone, but the transition is largely from agricultural uses to a more continuous forest cover.

An area in eastern Wisconsin along Lake Michigan is distinct from the rest of the northern forest due to the Lake's climatic moderation, and the influence of the Niagara Escarpment's dolomitic limestone bedrock. Maps of historic and current land cover are found in the Statewide Maps section of this Handbook.



Figure 1. Approximate location of the Tension Zone in Wisconsin (WDNR 1995, modified from Curtis (1959)).

The shorter growing season in northern Wisconsin, away from Lake Michigan, makes this area less suitable for agriculture and allows forest to predominate. Data from the Forest Inventory and Analysis (FIA) (Schmidt 1997), shown in Figure 2, indicate that the area is 58% timberland (10.9 million acres) and 42% non-forested or marginally productive (7.9 million acres). The northern forests represent 69% of forested area statewide. The area is less populated than the southern part of the state, and less developed, although vacation home construction is increasing.

Today's northern forest is characterized by broadleaf deciduous tree species, with a lesser proportion of conifers. About 30 native tree species can be found in the northern forest. Tree species composition at each locality varies depending on characteristics of the glacial landform providing the substrate, and on past human activities and natural disturbance.

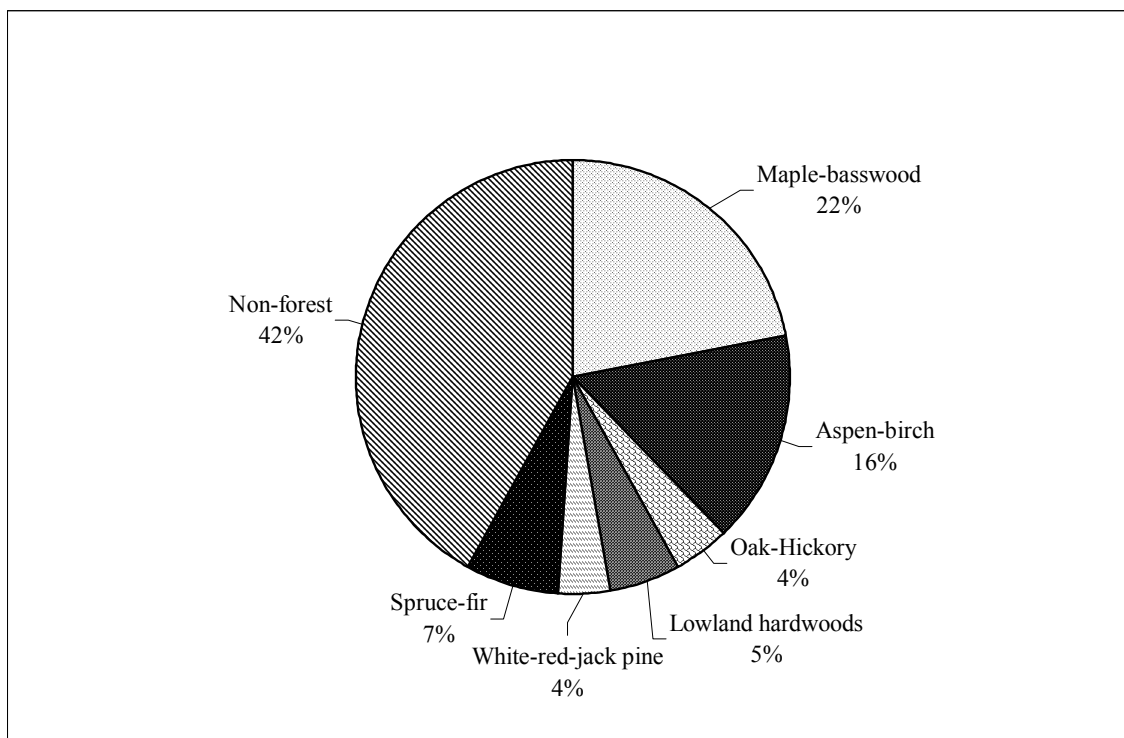


Figure 2. Proportions of forested and non-forested lands, and forest type groups, on land area north of the Tension Zone in Wisconsin, as inventoried in 1996 by FIA (Schmidt 1997).

Within the 10.9 million acres classified as timberland, forest type groups have been identified and measured by the FIA (Schmidt 1997). There are a number of different ways to define forest types. FIA uses major tree species or groups of species that commonly occur together. A forested area is classified as one type or another based on tree species that form a “plurality” (the largest proportion, based on the number of stems of live trees greater than 1 inch in diameter). Because many forests contain a mixture of species, an area may actually include anywhere from 20%-100% of the species in the named type. Although the system has shortcomings, FIA methodology is more statistically valid over large areas than other measures of forest composition. Percentages of the various forest types are shown in Figure 2.

Maple-basswood is the most common forest type group in the northern forest, occupying 22% of the land area and making up 38% of the timberland area. This community includes sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), red oak (*Quercus rubra*), quaking aspen (*Populus tremuloides*), yellow birch (*Betula alleghaniensis*), and eastern hemlock (*Tsuga canadensis*) (Curtis 1959).

The second most common forest type group in the north is aspen-birch. It occupies 16% of the land area, and makes up 28% of the timberland area. Quaking and big-tooth aspen (*Populus grandidentata*), paper birch (*Betula papyrifera*), red maple, and balsam fir (*Abies balsamea*) are important species in this forest type group (Curtis 1959).

Other forest type groups found in the northern forest community are:

- Oak-hickory (4% of land area, 7% of timberland), including forests dominated by northern red oak, white oak (*Quercus alba*), and northern pin oak (*Quercus ellipsoidalis*), with components of red maple, aspen, white pine (*Pinus strobus*), black oak (*Quercus velutina*) nearer the Tension Zone, bur oak (*Quercus*

macrocarpa) or black cherry (*Prunus serotina*). Hickories (*Carya spp.*) are a minor component of northern forests (Curtis 1959).

- Spruce-fir (7% of land area, 12% of timberland), including white spruce (*Picea glauca*), balsam fir, black spruce (*Picea mariana*), northern white-cedar (*Thuja occidentalis*), and tamarack (*Larix laricina*). This type includes the swamp conifer and boreal forest types described by Finley (1976).
- Pine forests of white, red (*Pinus resinosa*) and jack pine (*Pinus banksiana*) (4% of land area, 7% of timberland).
- Lowland hardwoods with black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), red maple and silver maple (*Acer saccharinum*) (5% of land area, 9% of timberland). Silver maple is found only in floodplains associated with larger rivers. American elm is relatively common in lowland forests as saplings or small trees of 20 to 25 feet in height, but no longer reaches the forest canopy.

Non-forested or sparsely forested areas of northern Wisconsin include barrens, grasslands (agricultural fields or old fields), wetlands, and aquatic communities. These are described in separate community chapters.

Over time, forest communities will change through vegetative succession. An indication of possible future forest cover, in the absence of disturbance, can be obtained from the Habitat Type Classification System (Kotar et al. 1988). Ecological Landscape chapters of this Handbook list the habitat types found in each area.

Historic Vegetation

Historically, the northern forests were much different than today. The last glacial period ended in Wisconsin about 10,000 to 12,000 years ago, and vegetative succession occurred as the land warmed and species moved northward. At about 3,000 years ago, the tree species assemblages found in today's forests were all present in northern Wisconsin (Davis et al. 1993). However, dominance of the various species groups shifted in response to climatic fluctuations during the past 3,000 years in ways that cannot be completely documented.

General Land Office (GLO) survey information was collected in Wisconsin between 1832 and 1866, and these data provide an earlier picture of our vegetation. Finley (1976) prepared a map based on GLO information, classifying the northern forest area into a number of distinct vegetation types. Finley's map is shown in the Statewide Maps section of this Handbook as "Finley's Presettlement Vegetation". More recently, GLO information has been digitized and is in the process of being reanalyzed (Schulte et al. 2001). Ultimately, the reanalysis will provide more accurate and detailed information about the forests of the mid-1800s, but is not yet available in a form that permits characterization of broad forest types. Maps of the digitized GLO data are included in each Ecological Landscape chapter of this Handbook as "Forest Cover of the mid-1800s."

Finley's forest type categories for the Northern Forest area include:

Boreal Forest

- White pine, white birch, white spruce, balsam fir, tamarack, white cedar, and aspen made up this forest type (WDNR 2001). The boreal forests occupied about 550,000 acres (3% of land area), mostly restricted to the Superior Coastal Plain Ecological Landscape near Lake Superior. They resembled the true boreal forests of Canada in some ways, but their composition varied. For example, much of the area was strongly dominated by white pine (*Pinus strobus*) (D. Mladenoff, personal communication). The extent of boreal forest in Wisconsin was limited by climatic conditions. Windthrow, fire, and spruce budworm were among the important disturbance agents.

Mixed Coniferous-Deciduous Forest Types

- The *Jack pine and scrub oak forest* and *jack pine and scrub oak barrens* covered about 1.5 million acres (8% of land area). This forest type included a variety of successional states, ranging from dense jack pine forests, to areas sparsely forested with stunted oaks or oak-pine mixtures, to recently burned areas with few live trees remaining. The oak species were usually northern pin oak or bur oak. Other scattered tree

species sometimes found in these forests included red and white pine, red maple, aspen, and white birch. These forests were restricted to the extremely xeric portions of sandy outwash plains and glacial lakebeds. Much of the Northwest Sands Ecological Landscape was covered by this type. It also occupied large areas in the Northeast Sands and Central Sand Plains Ecological Landscapes. Species were fire-adapted, and vegetative communities were subject to frequent, intense fires. Insect outbreaks (e.g. jack pine budworm) often affected extensive areas of forest and contributed to fire intensity.

- The *White pine-red pine forest* occupied about 1.5 million acres (8% of land area). This is considerably less than logging-era folklore has led many people to believe. The Northern Highlands Ecological Landscape had the largest contiguous area of pines, but they also occurred along the margins of the Northwest Sands Ecological Landscape, throughout the Northeast Sands Ecological Landscape, and along the Tension Zone. These forests were mostly restricted to sandy areas formed by glacial outwash or lakebeds in the northernmost part of the area, but they also occurred on more productive soils along the Tension Zone where fire disturbance was extensive. Fire was the major natural disturbance that regenerated red and white pine forests, although insect outbreaks and windthrow often contributed to fuel buildup that led to fires. While catastrophic fires led to stand replacement, less intense fires often created open forest understories, or barrens and savannas.
- The *Hemlock-sugar maple-yellow birch-pine forest* occupied about 6.2 million acres (32% of land area). This vegetative type, often referred to as the hemlock-hardwood forest, was the largest and most characteristic forest of northern Wisconsin at the time of the GLO survey. Overall, hemlock made up about 21% of the trees, and yellow birch and sugar maple accounted for another 17% each, according to recent analyses of GLO data (Lisa A. Schulte, Univ. of Wisconsin-Madison, pers. comm.). Forests were patchy, dominated by hemlock in some places and combinations of sugar maple and yellow birch in others. They were mostly found on glacial till plains and moraines in the North Central Forest and the Forest Transition Ecological Landscapes. The glacial till substrate provided nutrients and moisture in moderate amounts as required by these forests, and they were well-adapted to the colder climate which restricted the abundance of many species commonly found south of the Tension Zone. The dominant natural disturbance, on an area basis, was mostly gap-phase windthrow that disturbed small patches of less than 1/10 acre (Tyrrell 1991). Under this disturbance regime, vast areas of the forest were able to age and become old-growth (Frelich 1995). Old-growth forests featured large quantities of dead wood, trees with cavities and broken branches or trunks, and tip-up mounds on the forest floor (Tyrrell and Crow 1993). Catastrophic blowdowns occurred, but impacted less area on average than gap-phase disturbance (Canham and Loucks 1984). There were also impacts from mid-scale wind disturbances, but the relative extent of this type of disturbance is unknown. Investigations of the age-class structure of old-growth forests show a periodicity, or clustering around several age-class groups, indicating that trees regenerated at intervals rather than continuously (Frelich and Lorimer 1991, Bourdo 1983, Loucks 1983). Two reasons suggested for this periodicity are competition for scarce soil moisture and nutrients (Loucks 1983), or mid-scale wind disturbances (C. Lorimer, pers. communication). Other factors, such as drought and insect outbreaks, may also have contributed.
- The *Sugar maple-yellow birch-pine forest* occupied about 2.1 million acres (11% of land area). This forest type was found south and west of the hemlock/ hardwood type. The type was classified separately from the hemlock-hardwoods because eastern hemlock is absent, as its range ends in Wisconsin due to climatic changes. Sugar maple-dominated forests may have been more associated with the richer glacial moraines, as sugar maple is more nutrient-demanding than hemlock. The disturbance regime was similar to that of the hemlock-hardwood forest, and these hardwood forests were also mostly in an old-growth condition at the time of the GLO survey.
- The *Beech-hemlock-sugar maple-yellow birch-pine forest* occurred on about 950,000 acres in northeast Wisconsin near Lake Michigan (5% of land area), and the *Beech-sugar maple-basswood-oak forest* occupied another 1.2 million acres (7% of land area). This forest type was classified separately due to the presence of beech in the eastern portion of Wisconsin. American beech is another species that reached the western limits of its range in Wisconsin, presumably due to climatic conditions. The disturbance regime was similar to that of the other hardwood forest types, and the beech-dominated forests were also mostly in an old-growth condition at the time of the GLO survey.

- The *Aspen-white birch forest*, often mixed with pine, occupied about 3.5 to 4.3% of the land area in northern Wisconsin, according to recent analyses of GLO data (Schulte et al. 2001). Finley mapped slightly less of this type; analysis of his map shows 315,000 acres (2% of land area). Many small patches of this type were scattered in the Northwest Lowlands Ecological Landscape, where they may have resulted from beaver activity. Several relatively large patches occurred in the Forest Transition, where they likely originated following fire.

Deciduous Forest, Grassland and Brush

Most of the Deciduous Forest types, as well as the Grassland and Brush types (Finley 1976) were found south of, or within, the Tension Zone. These vegetative types are discussed in the Southern Forests Community chapter.

Wetland Vegetation

Finley (1976) identified three wetland vegetation types. Two of them, the Lowland Hardwoods type and the Marsh and Sedge Meadow type, occur primarily south of the Tension Zone. One type was common in the Northern Forests.

- *Swamp conifers*, made up primarily of white cedar, black spruce, and tamarack, occupied about 2.7 million acres in northern Wisconsin (14% of land area). Most of these forests were found north of the Tension Zone in relatively small patches scattered throughout most of the Ecological Landscapes. A similar forest type on the Superior Coastal Plain was classified as the Boreal Forest. A wet substrate, either with standing water or a water table close to the land's surface, allowed these conifer forests to develop. Disturbance regimes varied, including flooding, windthrow, and occasionally fire.

Global / Regional Ecological Landscape Context

Globally, Wisconsin's northern forest community is part of the temperate deciduous forest biome. At about 8,000 years ago, when the climate stabilized after Pleistocene glaciation, this biome covered most of western Europe, eastern Asia, and eastern North America. Most of the original temperate forest has been cleared (World Resources Institute 2001). In Europe and Asia, deforestation often occurred because of needs for fuelwood and animal fodder. In North America, forest was cleared primarily to obtain timber and create farmland, or more recently to provide space for development (Spurr and Barnes 1980).

Wisconsin's northern forest lies primarily within the ecoregion known as the Laurentian Mixed Forest Province, as identified by the National Hierarchical Framework of Ecological Units (NHFEU) (Keys et al. 1995), and shown in Figure 3. The ecoregional Province boundary is based on continental climatic conditions that change in mid-Wisconsin. Climatic differences are reflected in the vegetative changes evidenced along the Tension Zone. The Laurentian Mixed Forest Province includes the northern portions of Minnesota, Wisconsin, and Michigan in the Lake States, and also includes areas of northern Pennsylvania and New York (although some ecologists consider the latter to be climatically distinct and have suggested separating them).

Within Wisconsin, the northern forest community lies within the Southern Superior Upland, Western Superior Upland, Northern Great Lakes, and Southwest Great Lakes Morainal Sections of the NHFEU (Figure 4). Sections are based on climatic differences within a Province, and also broad-scale glacial features. Many Section boundaries in Wisconsin coincide with the extent of glacial ice lobes during the Wisconsin Ice Age. Different glacial lobes are associated with characteristic soil and topographic attributes. There are 21 Subsections nested within the four Sections. Subsections are mapped based on associated groups of glacial landforms, including morainal systems, till plains, outwash plains, and lake plains. All of these glacial features have distinguishing soil and vegetation attributes, and different combinations of forest communities. The Ecological Landscapes used in this Handbook are based substantially on Subsections of the NHFEU.

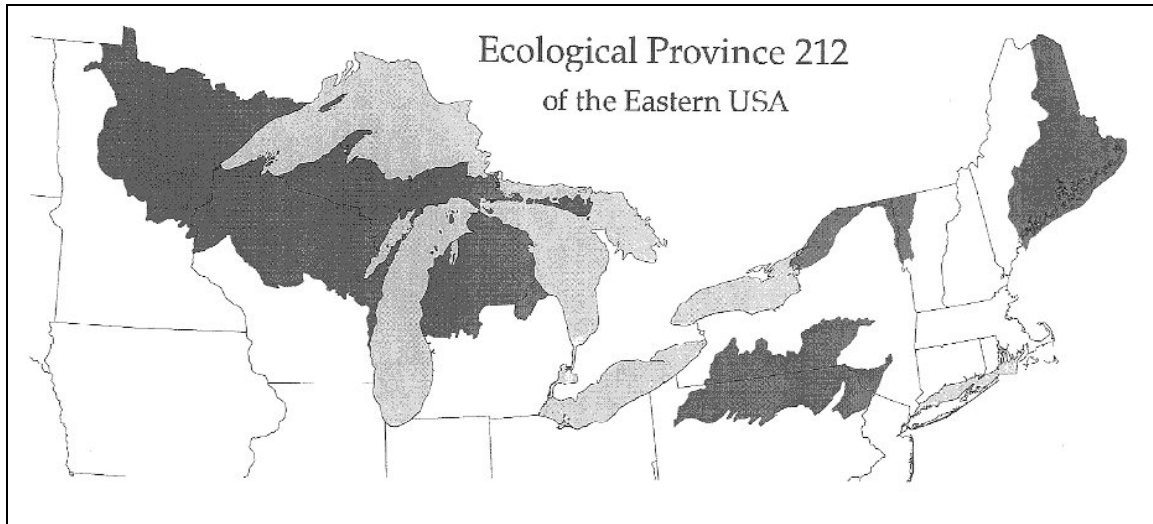


Figure 3. The Laurentian Mixed Forest Province (212) is a broad-scale level of land classification (Keys et al. 1995). Provinces are based largely on climatic gradients that control the distribution of biomes.

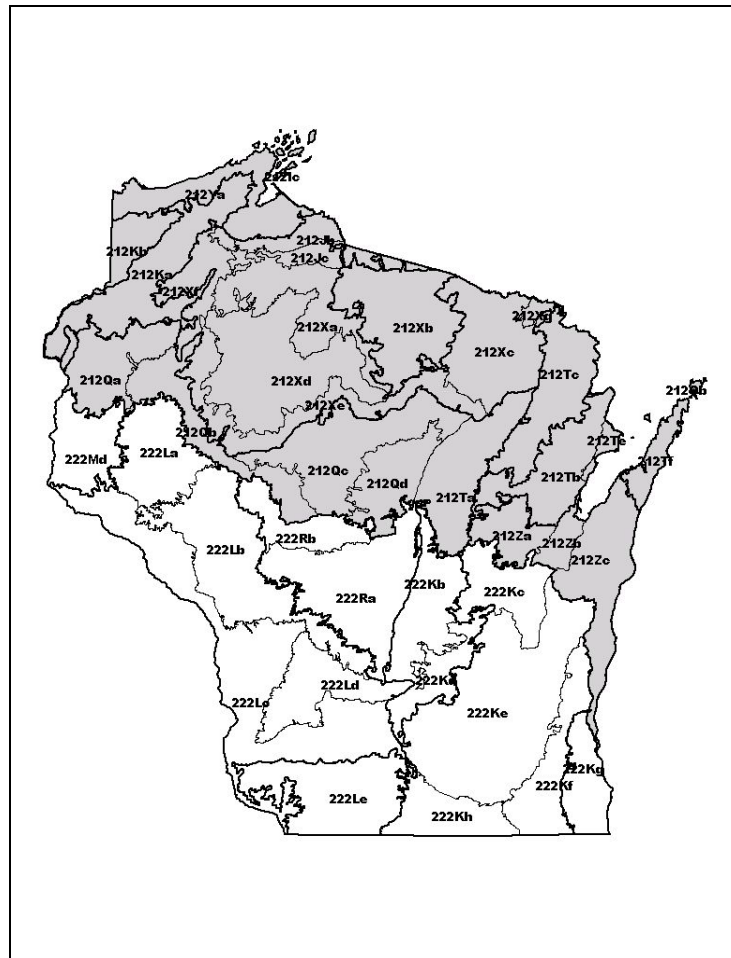


Figure 4. Subsection levels of the ecological land classification system (NHFEU) in Wisconsin. Province 212, the Laurentian Mixed Forest, is shaded. Its southern boundary approximates the Tension Zone in Wisconsin. Ecological Landscape boundaries are shown as heavier lines.

Northern Wisconsin, at the time of Euro-American settlement, included the largest and most contiguous expanse of hemlock-hardwood forest in the Lake States. Today, the area is still the largest expanse of maple-dominated hardwood forest, offering the best possibilities for maintaining interior forest conditions in large patches. Wisconsin's northern forest is a center of abundance, as well as the center of the breeding range, for many neotropical migratory songbirds of global significance (Howe et al. 1996). A globally rare community type, the pine barrens, is found on outwash sands within the northern forest. The boreal forest is another unusual community type that has decreased greatly from its former extent. The Niagara Escarpment, an area of dolomitic limestone that outcrops in the Door Peninsula and other parts of northeastern Wisconsin, is associated with a number of rare plants, land snails, and globally rare community types. Lakes and streams, particularly the concentration of kettle lakes in some locations, are other significant features of northern Wisconsin. The area also contains the headwaters for most of Wisconsin's major rivers.

Assessment of Current Condition

The current condition of the northern forest is a function of the physical and biological environment that existed prior to Euro-American settlement, as well as human actions since that time. Forest ecosystems were drastically disturbed between the 1850s and early 1930s when nearly all of the primary forest was harvested or burned during the "Cutover." Figure 5 shows the extent of primary (virgin) forest in 1870 and 1932.

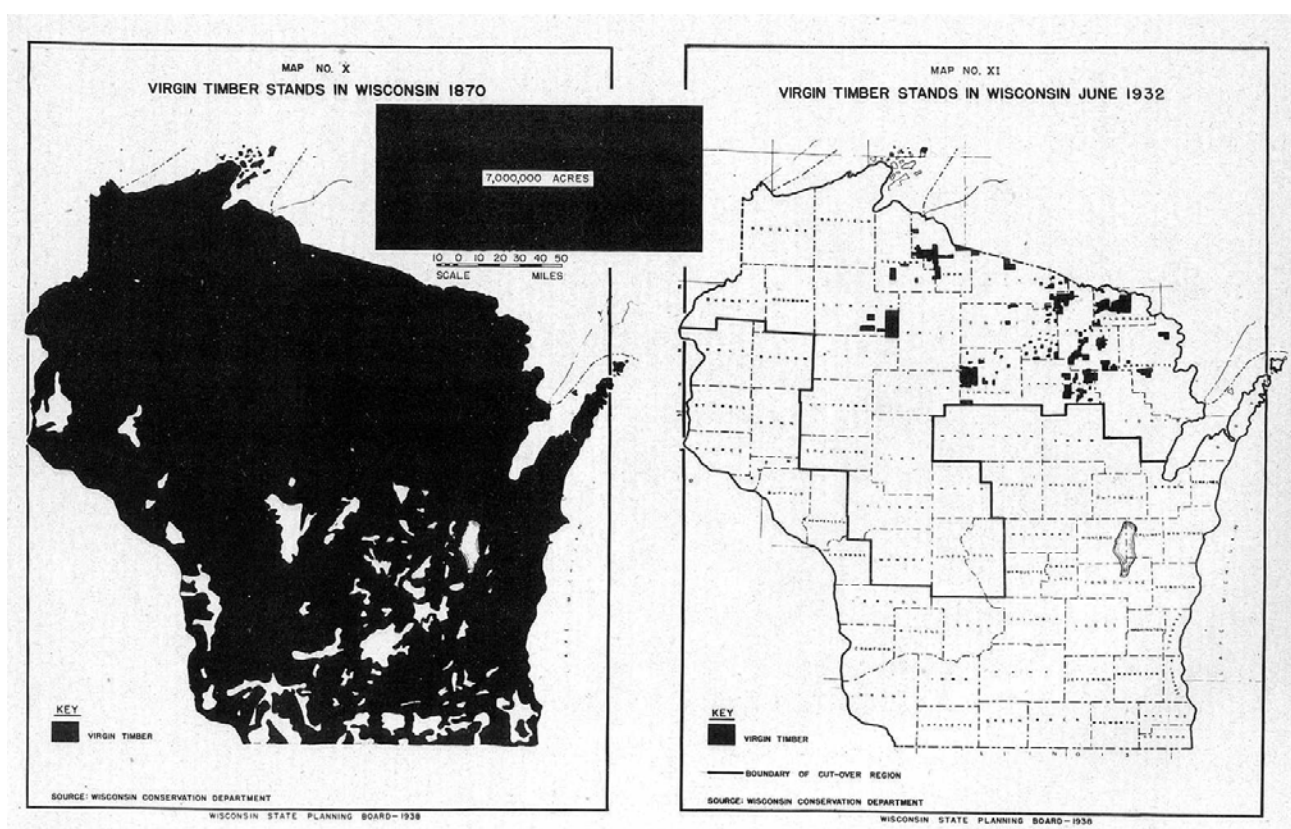


Figure 5. Primary forest in Wisconsin, 1870 and 1932 (Wisconsin State Planning Board 1939).

Cutover-era logging began near large rivers as early as the 1830s. During this period, trees could only be cut with axes and transported via river systems. These constraints required loggers to focus on pines because they were easier to cut and light enough to float. It was difficult to transport logs on land, so logging did not expand very far from rivers. Principal logging rivers included the Wisconsin, Chippewa, Red Cedar, Black, St. Croix, and rivers in northeastern Wisconsin (the Wolf, Peshtigo, Oconto, and Menominee) (Connor 1978, Wells 1978). The areas logged first were the “pineries,” which were thickly forested with white pine.

It is difficult to say how much timber was removed from northern Wisconsin during the period before the Civil War. Records indicate that some of the first buildings in Madison were made of timber cut near Wisconsin Rapids in 1837. In 1848, lumbering on the Yellow River produced 700,000 board feet (BF) in one winter. The Green Bay General Land Office estimated in 1849 that 15 million BF were being removed annually from that region. In the same year, 37,000 logs were floated down the St. Croix River. By the late 1850s, there were major lumber towns at Green Bay, Sheboygan, Fond du Lac, Oshkosh, Wausau, Eau Claire, Chippewa Falls, and La Crosse. There was little respect for authority during the Cutover. Of 500 million BF of lumber shipped from eastern Wisconsin between 1844 and 1854, it is estimated that 90% was stolen from government lands (Wells 1978).

The Civil War led to prosperity and expanded manufacturing capability in the North, which in turn led to expansion of railroads. By 1870, logging in the north woods was changing. Crosscut saws replaced axes, horses replaced the slower oxen teams, and railroads allowed logging to move inland, away from the rivers. Narrow gauge railroads were able to get into many previously inaccessible forests, and allowed logs to be transported year-round. It became profitable to remove the pine component from hardwood forests, even when there were only a few large pines on an acre of land. Speculators acquired millions of acres of forest from the government, later making huge profits as the timber was liquidated. “Homesteaders” were often frontmen for lumber companies; they acquired quarter-sections of land in the pineries, built shacks, let the loggers take the pine, and disappeared without paying a cent to the government. The rate of cutting in the pineries increased rapidly (Wells 1978).

Starting in the 1870s, fires began to have a major effect on the forest. Fires were often started accidentally by sparks from passing trains, or deliberately set for land clearing or cooking. When conditions were dry, as they were during the season that led up to the catastrophic Peshtigo fire of 1871, fire spread furiously through the slash (tops and limbs) left after logging. Meanwhile, in the pineries that had been logged starting in the 1830s, white pine forests were regenerating and growing rapidly, but they did not survive. Wildfires destroyed the young pine forests and eliminated most seed sources that could have provided for subsequent regeneration.

During the 1880s and 1890s, pine logging was at its peak in Wisconsin. The average cut between 1888 and 1898 was more than 3 billion BF annually. A government report published in 1898 estimated that of the original 130 billion BF of pine in Wisconsin, about 17 billion remained. Over 8 million of the 17 million acres of forest land in the northern counties was cutover, largely burned over, vegetated with “waste brush”, or “nearly desert.” Rivers were clogged with sediment from log drives. Many were no longer navigable and their flow rate had decreased, making them less effective for producing power. Changes in drainage and soil moisture occurred because of the removal of forest cover and construction of roads and railroads, so that many wetlands became dry fields or upland forests (Roth 1898).

By the turn of the century, pine logging was nearly finished. Lumber barons moved on to the Pacific Northwest. The companies that remained began cutting the formerly scorned hardwoods. Pulp mills were constructed to utilize the less-desirable wood, beginning the gradual switch to a pulp-dominated industry. Production of sawtimber declined sharply, falling to 367 million BF by 1935. By 1937, more than half the employees in forest manufacturing were employed in making paper products. Efforts to sell the cutover lands to settlers were underway, often with false enticements regarding the fine quality of the soil and the beneficial climate (Wisconsin State Planning Board 1939).

During the period between about 1900 till 1930, hemlock and hardwoods were removed, often by clearcutting, or by high-grading. Hemlock was taken for its bark, which was peeled in the woods during the spring and early summer, and shipped to tanneries. The hemlock logs were generally used for lumber or pulp, although some were left to rot in the woods when demand was low, or were used as fill beneath railroads. After a forest was accessed for hemlock bark, removal of hardwoods soon followed, often as soon as the following winter (Corrigan 1978).

Railroad logging declined after the 1930s due to improvements in highways and trucks. Selective logging began in the 1920s, and although much of this was high-grading, some longer term sustained-yield management also emerged. In either case, selection cutting did not produce the immediate profit levels of clearcutting, and so necessitated the use of lower-cost transportation (Kaysen 1978).

The paper industry had its start early in Wisconsin's history. The first mill used rags as its source material, beginning operation in Milwaukee in 1848. Wood pulping by the groundwood method, a mechanical process, began in 1871 using spruce, aspen, and basswood. Hemlock was also used for pulp after development of the sulfite pulping method in 1887. These methods provided material for newsprint production through the 1920s. The sulfate, or kraft method, was introduced in 1911, allowing pines to be used significantly. Mixed hardwoods became an important source material only after the development of semichemical pulping in 1948. Different species were used more heavily at various times. Records show that in 1908 aspen provided only 1% of pulpwood receipts, and was not a major part of production till about 1950 (McGovern 1979).

Public reaction to the abuses of the Cutover resulted in legislation and government programs designed to rehabilitate the ruined forests. Fire control programs were established by law in 1911, the same year that state nurseries began producing tree seedlings for replanting. In 1924, legislation was passed enabling the state to engage in a forest improvement program. Tax delinquency on lands where agriculture had been attempted was pervasive by the 1920s, and counties acquired many of these lands for county forests. The first land purchase for the Nicolet National Forest took place in 1928. The Civilian Conservation Corps operated between 1933 and 1942, planting over 2 billion trees in cutover areas, mostly jack pine and red pine (Wisconsin State Planning Board 1939). These events and ideas, along with natural regeneration and succession of forest species, gradually led to the forest conditions and practices of today.

The former pineries are now mostly forested with northern red oak, red maple, and aspen (WDNR 1995). White pine has begun to regenerate in parts of northern Wisconsin where seed sources exist and environmental conditions are favorable. Suitable areas include moister sandy soils, and areas where sands and morainal till soils are intermingled.

Aspen, which produces abundant wind-dispersed seed, was well-adapted to colonize the logged-over lands that were widespread in the early 1900s. By the time of the first FIA survey in 1935, the aspen-birch forest type was found on over 4 million acres in northern Wisconsin. Of this area, 3.2 million acres were "restocking land" not yet of commercial value (data from FIA economic units 1 and 2, Cunningham and Moser 1938).

Hemlock still exists as a component of the northern hardwood forests, but is greatly reduced from levels found in the 1800s. FIA data show that it currently makes up about 3% of basal area in the northern forest (Schmidt 1997). A survey of state and county forests in the mid-1990s found that for these lands, hemlock-dominated forest stands made up 0.8% of the area (Eckstein 1995).

Hardwoods regenerated successfully after the Cutover, partly because they were less susceptible to fire. Roth (1898) noted that: "Where heavy hard woods and hemlock predominate, and pine is a scattered admixture, ground and litter is usually damp and fires run only during exceptionally dry seasons." Also, by the time these forests were heavily logged in the 1900s, wildfires were coming under control.

The northern forest community still contains the richness of tree species and forest community types it had at the time of Euro-American settlement, but the relative abundance of species has changed. Some have declined considerably, such as American elm, which now makes up about 1% of basal area for trees in the northern forest. Some tree species are of present concern due to problems with regeneration (e.g. hemlock, yellow birch, and white cedar). Other species have declined since the 1940s due to natural succession, including aspen and paper birch. Sugar maple has greatly increased its dominance because of the removal, decline, or loss of competing species (e.g. white pine, elm, hemlock, yellow birch) that were part of the original hemlock-hardwood forest. Forest management practices and herbivory have also contributed to the dominance of sugar maple.

Ecological concerns in the northern forest are generally focused on community composition, structure, and function. Natural disturbance processes of wind, fire, and flooding are not able to function in today's technology-influenced landscape as they did in the past. Land use changes have led to homogenization in patch sizes (Mladenoff et al. 1993), reductions in patch diversity (White and Mladenoff 1994), and simplification of forest communities (loss of diversity caused by declines of some species and increased dominance by others) (Schultz et al. 2001, Anderson and Loucks 1979). The mixed coniferous-deciduous forests have, with few exceptions, lost most of their conifers and much of their shrub layers, especially Canada yew.

Other issues in the northern forests include fragmentation and edge effects (Fenske and Neimi 1996, Flaspohler et al. 2001, Hamady 2000, McRae 1995, Pearson and Niemi 2000), excessive herbivory (Wisconsin Conservation Congress 2000), introduction of non-native invasive species, and declines of less-common species (Waller et al. 2001, Rooney et al. 2001). Older forests over 100 years in age are almost entirely lacking and the already limited extent decreased statewide between 1983 and 1996 (Schmidt 1997). Many species have declined due to human impacts, and northern Wisconsin now has a total of 544 species that are state or federally listed as endangered, threatened, or special concern. Of these, 212 species are plants. Others are mammals, birds, fish, reptiles, amphibians, mussels, invertebrates, and arthropods. There have been 8,121 documented occurrences of these species (WDNR, BER 2001). Additional detail about northern Wisconsin's ecological and socioeconomic issues is found in the following sections, and in the Ecological Landscape chapters of this Handbook.

Issues of Composition, Structure and Function

Composition

- Eastern hemlock and yellow birch, which were among the dominant trees in pre Euro-American settlement forests, are now relatively uncommon. FIA data collected in 1996 for Province 212 show that hemlock makes up only 2.8% of basal area (BA) in the maple-basswood forest type and yellow birch 2.2% (FIA 2001).
- Northern white cedar acreage decreased by 16% between 1983 and 1996 (Schmidt 1997, using data for Northeast, Northwest, and Central FIA Units).
- Jack pine acreage decreased by 27% between 1983 and 1996 (Schmidt 1997, using data for Northeast, Northwest, and Central FIA Units). The decline is largely due to high mortality and salvage harvesting in response to extremely high jack pine budworm populations.
- White pine is much less common than in pre Euro-American settlement times. It is increasing in the understory of many forests, but as a forest type its acreage decreased by 17% between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units).
- The boreal forest has been reduced in extent due to conversion to agriculture and other forest types, mostly aspen.
- White (paper) birch acreage declined by 29% between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units) due to succession. White birch is an early successional species that declines in the absence of fire or human-caused disturbances that expose mineral soil.

- Sugar maple is increasing its dominance in northern hardwood stands, and may be outcompeting conifers and other species that formerly regenerated in small gaps or on dead woody debris. This process contributes to forest simplification. Deer herbivory has been shown to be one of the factors that gives sugar maple a competitive advantage (Frelich and Lorimer 1985, Anderson and Loucks 1979).
- Butternut canker and salvage harvests reduced butternut volume by 36% statewide, but by only 7% in the northern forest, between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units). Butternut is not a common species in the northern forest.
- Aspen forest type acreage declined by 8% between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units). Extensive acreages of mature aspen existed in 1983 and these have been harvested; extent of aspen forests younger than 40 years of age is about the same in 1996 as it was in 1983 (Schmidt 1997, Spencer et al 1988). Aspen is still much more abundant than before Euro-American settlement. The aspen forest type, based on 1996 inventory, makes up 13.5% of the land area in Province 212 (the aspen-birch forest type group makes up 15.7%), as compared with about 3.5-4.3% aspen and aspen-white pine forest at the time of the GLO survey. Aspen continues to be actively promoted via management.
- American elm declined 77% in volume between 1983 and 1996 due largely to Dutch elm disease and salvage harvests, and partly because of succession to sugar maple (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units).
- Red pine acreage increased by 26% between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units) because of planting. Natural red pine forests are rare and are probably decreasing in extent as they age.
- Forested acreage continued to increase slightly (by 4% of current forest area) between 1983 and 1996 (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units), mostly due to reforestation of agricultural lands.
- Certain herbaceous plants are declining in abundance, particularly those that: 1) were rare historically; 2) require a specific insect species for pollination; 3) are small in stature; 4) are not able to disperse their propagules widely; or, 5) are heavily browsed by white-tailed deer (Waller et al. 2001, Rooney et al. 2001, Wiegmann 2001).
- Invasive exotics such as common buckthorn (*Rhamnus cathartica*), tatarian honeysuckle (*Lonicera tatarica*), reed canary grass (*Phalaris arundinacea*) and garlic mustard (*Alliaria petiolata*) are invading portions of the northern forest. These species have the potential to drastically change the composition of shrub and herbaceous layers of forests, as well as inhibiting tree regeneration.

Structure

- Old-growth developmental stages for all late-successional forest types are greatly reduced from pre Euro-American settlement times (Frelich 1995). Today's young, early- to mid-successional forests lack some compositional, structural, and functional attributes of older forests. Coarse woody debris in old-growth forests was larger, more persistent, and more abundant. Old-growth forests also contained many trees with cavities and broken tops that provided nest sites for wildlife.
- The average age of long-lived tree species continued to increase, but the area occupied by stands more than 100 years old decreased from already low amounts between 1983 and 1996 (Schmidt 1997, Spencer et al. 1988). See Figure 6.
- The loss of large trees, and in particular large supercanopy conifers, is a structural change as compared to pre Euro-American settlement conditions, and affects wildlife habitat and ecosystem processes.
- Pine forests with open understory and park-like structure created by low-intensity fire disturbance are very scarce.
- Shrub layers, particularly those composed of Canada yew (*Taxus canadensis*), are lacking in today's maple-dominated forests. Younger, even-aged forests that are overbrowsed by deer are the cause of much of this decline. This is to the detriment of wildlife that prefer them for nest sites, foraging, or cover.
- Large block, interior and all-aged forests are under-represented as compared to pre Euro-American settlement forests. Current forest cover is a patchwork of many similar-sized stands (Mladenoff et al.

1993). Large forested patches are lacking. This affects some species that require continuous, connected forest. Also, gap-phase disturbance that results from fine-scale wind disturbance is believed to be lacking in the second-growth northern hardwood forests. These trees, being younger than the historic forests, lack structural characteristics of aging that would make them more susceptible to windthrow. The lack of very small gaps can be an impact on wildlife and tree species that are more competitive in partially open forest conditions.

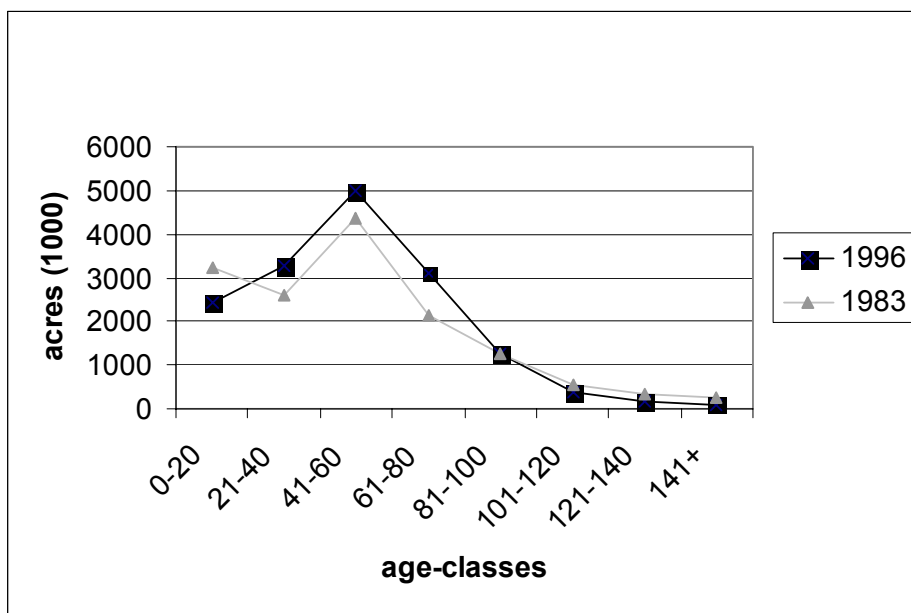


Figure 6. Forest stand age-classes and acreages in each class, 1983 and 1996, including all forest types, and all of Wisconsin's timberland (Schmidt 1997, Spencer et al. 1988).

- More roads continue to divide forest communities, impacting composition, structure, and functional processes.
- Vernal pools are important features for amphibian and invertebrate reproduction. Due to concerns for declining populations of some of these species, forest management guidelines often advise that equipment should avoid vernal pools, and that slash should not be piled in them. It has been suggested that vernal pools may be less abundant in the northern forests than they were prior to Euro-American settlement due to reductions in pit-and-mound topography, or changes in surface drainage patterns associated with roading. However, quantitative information on the amount and condition of vernal pools in northern Wisconsin is lacking.
- Clear-cutting of aspen has kept significant acreages in an early succession stage, reducing both vertical and horizontal diversity. The total amount and also the spatial dispersion of aspen is at issue because of the creation of edge and habitat fragmentation. Also, size limits on clearcuts have reduced their effectiveness as habitat for species such as sharp-tailed grouse, upland sandpiper, and northern harrier that use early-successional landscapes.
- The ongoing process of residential and commercial development has led to habitat loss, permanent fragmentation, and changes in landscape composition, structure and function. Other consequences of a human population in the forest include predation by cats and dogs, incursions of generalist species like raccoon and skunk, and wildlife baiting and feeding.
- Habitat fragmentation and edge effects are of concern in the Northern Forests, largely because dispersion of harvests throughout the forest creates differences in structure. Concerns associated with fragmentation and edge are different than those found in agriculture-dominated landscapes. Studies of forest neotropical migrant bird species show that nest predation, not cowbird parasitism, is the most important factor

limiting nest success in the northern forests. More research is needed, as effects vary by locale, but studies have found increased predation of certain species in proximity to forest edges (Fenske and Neimi 1996, Flaspohler et al. 2001). Changes in interspecific competition are a related issue, and impacts on forest specialist bird species have been found in forest openings (Hamady 2000). Landscape composition, including the relative dominance of forested and non-forested patches, and the inclusion of conifer components, appear to play roles in habitat selection. Some forest specialists will occupy less-preferred habitats if the surrounding area has desirable attributes or components (McRae 1995, Pearson and Niemi 2000).

Function

- Excessive herbivory (by white-tailed deer and sometimes snowshoe hare) is impacting the reproductive potential of several key tree species as well as certain understory plants. Community simplification is one of the results (Schulz et al. 2001, Frelich 1995, Anderson and Loucks 1979).
- Forest diseases and insects are an increasing problem due to the continual introduction of non-native species. Oak wilt is damaging red, black and northern pin oak in the southern portion of the northern forest. Gypsy moth populations are gaining ground in some northern forest segments. Jack pine budworm outbreaks resulted in extensive mortality and salvage harvesting over the past decade. Beech bark disease and hemlock woolly adelgid are future concerns.
- Wildfire suppression continues, reducing its role as a natural disturbance factor in the pine forests. Fire fuel-load is growing in some areas because of fire suppression, which could lead to more severe fires. In other areas, jack pine forests have been converted to other, less flammable, forest types.
- Mid-successional forests are less susceptible to windthrow disturbance, resulting in fewer forest gaps and a lack of trees with broken limbs and tops. The lack of these features affects wildlife populations.
- Invasive plants continue to increase and spread, sometimes outcompeting and replacing native species.
- Damaged riparian forests allow bank erosion and sediment input. Lack of large trees along shorelines limits recruitment of large woody debris into lakes and streams. Voluntary BMP's (Best Management Practices) may reduce some of these impacts.
- Elk, American marten, fisher, and wild turkey were reintroduced into northern Wisconsin and may be permanently established, although marten and elk are currently limited to restricted areas of suitable habitat.
- Timber wolves returned to Wisconsin through Minnesota recently and are now established in many parts of the north.
- Populations of most neotropical migratory songbirds are of high conservation concern. Wisconsin's forests are centers of abundance for some of them, and may be source habitat for several broadly distributed species. A number of species have been suggested as high priorities for management (Howe et al. 1996).
- Soil compaction can occur from the passage of heavy equipment, particularly on moist loamy soils, resulting in slower growth or poor regeneration of some tree species.
- Pollution has not been recognized as a large impact in most of the northern forest. However, ground-level ozone could impact sensitive tree species like aspen and white pine in areas near the Fox Valley. Also, nitrate leaching in excess of precipitation inputs has been documented for several forested sites in northern Wisconsin, indicating that the ecosystems may be N-saturated (Bockheim 2001).
- Climate change could drastically affect northern forests, allowing oak-dominated forests to move north, and boreal forests to be lost in Wisconsin. Many wetland forests could also change to drier forest types.

Land Use and Environmental Considerations

- Wisconsin is one of the nation's top producers of forest products. The state is ranked highest in the nation in forest products industry employee compensation, value of shipments and capital expenditures. It ranks second in number of employees. The pulp and paper industry produces most of the products and employs

more people than other sectors of the forest industry. Forestry-related employment provides jobs and relatively high pay for rural residents.

- Of the approximately 37 counties within the northern forest, the forest products industry is the major employer in 27 of them, ranks second in three, and is third in four.
- Only 18% of commercial timber sales on lands in private, non-industrial ownership benefit from professional forestry assistance. High-grade logging continues on a significant acreage of private forestland (WDNR 1999).
- Clear-cutting, a harvest method used to regenerate species like aspen that require high light levels, is controversial for ecological and aesthetic reasons.
- FIA measures of agricultural cropland show decreases between 1983 and 1996, while "idle farmland" increased. (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units)
- Some agricultural riparian zones are being ecologically degraded, especially where continuous grazing is practiced. Voluntary BMPs are being applied to timber harvests in forest riparian zones.
- Primary home, second home, and commercial development are growing and encroaching on forestlands and riparian zones.
- Tourism in the north is increasing, especially in counties with many lakes and along the Great Lakes.
- Road density, not including unimproved forest roads and trails, averaged 1.1 mi/mi² in northern Wisconsin based on data compiled in 1991 (Mladenoff et al. 1995). Road density is likely increasing due to development, but current data are not available.
- Off-road vehicle use has increased in recent decades, and demand for this form of motorized recreation continues to increase. Combining motorized and non-motorized recreation in the same area leads to conflicts among recreational users. Environmental impacts of off-road vehicle use have been observed, but are not well-documented.
- Undeveloped northern lakes were inventoried in 1960; 60% of those are now developed. Only 3% of northern lakes 200 acres or larger remain undeveloped (1000 Friends of Wisconsin and the Land Use Institute, 2001).
- Public forest classed as timberland increased by 300,300 acres (2.3% of forested lands) between 1983 and 1996; however, this increase is largely due to changes in the way the FIA program classifies land. Some lands formerly in the "reserved" category are now classified as timberland. (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units).
- Unmanaged forests are of limited extent in northern Wisconsin. Only 142,100 forested acres (1.1% of forested lands) are "reserved," or withdrawn from timber utilization (Schmidt 1997, using data for the Northeast, Northwest, and Central FIA Units).
- Designated wilderness areas are of small extent. National Forests have about 44,000 acres of designated wilderness, and the State Forests have approximately 13,500 acres. State Parks managed as wilderness occupy about 2,400 acres.
- Population levels continue to rise, increasing pressure on many forest resources.
- User interests in forested land often conflict.
- When ownership of large forest areas changes or when owner objectives change, there may be influences and pressures on other landowners and resources.
- Citizen involvement in public land planning is increasing.
- Public knowledge about managing natural resources is highly variable.

Northern Forest Community Ecological Opportunities

There are opportunities to apply ecological principles in considering forest type composition, and to change the representation of certain types. Possibilities to consider include the following:

- **Maintain or increase acreage** of the following forest types:
 - Hemlock (all Ecological Landscapes within its range). Formerly widespread and abundant in many areas, it is now reduced or absent from many appropriate locations.

- Northern white cedar (all Ecological Landscapes). Research is needed to learn more about requirements for regenerating this species, although reduction of deer populations may offer a partial solution.
 - Jack pine (NW sands, NE sands, & Central Sand Plains Ecological Landscapes). Acreages have been reduced recently due to mortality and salvage harvests after a jack pine budworm outbreak, and in some areas, changing landowner objectives and a desire to feature other species. Suitable areas for jack pine are of limited extent in Wisconsin.
 - White spruce, balsam fir and white pine in the boreal forest (Superior Coastal Plain Ecological Landscape). The boreal forest is an important and distinctive community type, although geographically limited in Wisconsin.
 - White birch (all Ecological Landscapes), although this was and will be a minor forest component.
- Consider the following management options in appropriate areas. The Landtype Association level of the NHFEU may be used in identifying suitable areas at a finer scale.
 - **Old growth communities.** Designate and increase acreage in all Ecological Landscapes where appropriate. Several types are especially important due to past extent and current scarcity, including the hemlock-hardwoods, northern hardwoods, and red and white pines.
 - **Aspen.** Stabilize a determined acreage and distribution pattern, perhaps associated with certain Ecological Landscapes.
 - **Idle agricultural land.** Determine the desired future forest type in all Ecological Landscapes. Include habitat needs for open lands.
 - **Sugar maple.** Manage for greater vegetative and structural diversity in northern hardwoods. Include a component of large conifers as well as large hardwoods to provide structural diversity and eventually, snags and coarse woody debris that are of large diameter and persistent in the ecosystem. Retain some fallen logs after harvest, and allow a component of the forest to reach its natural lifespan. Manage to include a component of hemlock, yellow birch, cherry, and white ash in areas where they are no longer present or have been greatly reduced. Increase representation of old-growth hardwood forests, especially on very rich sites where older age-classes are presently lacking.
 - **White pine.** Encourage development of this component in existing forests (in suitable portions of all Ecological Landscapes).
 - **Butternut and American elm.** Encourage retention and development in their ranges (in all compatible Ecological Landscapes, mostly in the Southern Forests community).
 - Reduce negative impacts of herbivory on sensitive species (all Ecological Landscapes). Manage deer populations at established goals.
 - Manage threatened and endangered plant and animal species on a community and landscape basis whenever and wherever feasible (all Ecological Landscapes).
 - Continue to retain representative natural communities. Seek tax incentives for landowners who wish to restore or maintain natural communities (all Ecological Landscapes).
 - Reconnect disjunct forest patches to reduce habitat fragmentation (all Ecological Landscapes).
 - Maintain existing large patches of northern hardwood forests (in North Central Forest Ecological Landscape).
 - Lengthen rotations of long-lived species to add missing age and structural diversity, and explore the use of extended rotations of short-lived species to add structural diversity in the short term (all Ecological Landscapes).
 - Promote species diversity when establishing and thinning plantations (in all Ecological Landscapes). Or, alternatively, identify areas where high volumes of wood can be produced in plantations in lieu of harvesting sensitive areas. Develop agreements to ensure that the offset in harvesting takes place.
 - In forest management, emulate, in part, the patchiness and variability of natural fire and wind disturbance regimes (suitable Ecological Landscapes). This could involve leaving a green tree

component in clearcuts, or using group selection harvests to create patch openings in sizes similar to natural disturbances.

- Close roads (with gates, berms, or similar structures) following timber sales to minimize impacts of off-road vehicles (all Ecological Landscapes). However, do not obliterate all woods roads. Overall levels of soil compaction can be reduced by using the same roadbed again during future harvests. Do not seed roadbeds with aggressive non-native species; favor native plants or allow the area to revegetate naturally.
- Maintain the condition of woods roads and trails kept permanently open, to reduce soil and water impacts.
- Document and control the adverse impacts of off-road vehicles.
- Prevent and control the spread of invasive non-native species to the extent possible; prioritize and monitor the species of greatest potential threat (all Ecological Landscapes).
- Restore degraded riparian zones (all Ecological Landscapes).
- Continue to encourage use of BMPs for water resources. Develop BMPs for vernal pools (all Ecological Landscapes).
- Consider scale and context in making decisions on retention and restoration.

In summary, the intent of these opportunities is to establish all characteristic successional stages, age classes, and patch sizes and distributions, at landscape and regional scales. The management goal is to emulate the natural variability of composition, structure and function within forest communities.

Under the ecosystem management framework, ecological, social, and economic conditions are considered during planning and implementation of DNR activities. This includes the process of identifying forested lands for protection, acquisition, or restoration, as well as practicing sustainable forest management. Ideally, an alternative acceptable in ecological, social, and economic contexts would exist. In practice, some decisions will favor ecological concerns, while others will be based more heavily on social or economic factors. Because ecological sustainability is required for long-term sustainability of economic systems, decisions under ecosystem management would not compromise ecological systems to the extent that their long-term sustainability would be impacted.

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The northern hardwood forest, dominated by sugar maple, is currently the most common forest type in northern Wisconsin. Its bright fall colors attract many visitors, but biologists are concerned about lack of diversity.



The mixed deciduous-coniferous forest, seen here at Cathedral Pines in Menominee County, is characteristic of northern Wisconsin. A lack of conifers in some second-growth forests is an issue because coniferous trees are an important habitat feature for many wildlife species. Photo by WA Smith.



Jack pine forests are found on dry sandy areas in northern Wisconsin, notably the Northwest Sands Ecological Landscape. This jack pine barrens, a Great Lakes variant, is found on Long Island in Ashland County. It demonstrates the typical patchy structure of the jack pine barrens community type. Photo by Eric Epstein.



Red pine plantation forests are a common sight in northern Wisconsin. This plantation is being row-thinned, a process in which one row of every three is removed. Thinning allows the remaining trees to grow faster. Photo by Darrell Zastrow.



The aspen-birch forest type is the second most abundant kind of forest in northern Wisconsin. This aspen formed a dense stand by root sprouting after a clearcut harvest, but now, spruce and fir are coming up in the understory and will eventually replace aspen unless another harvest occurs.



Prescribed fire can be used in pine or pine-oak forests, like this jack pine-scrub oak mixture. Many species in these forests are fire-adapted; and some jack pine trees require fire disturbance to open cones and release seed. Photo: North Central Research Station, US Forest Service.



White pine was the first, and most desirable, tree species removed during the Cutover. Repeated fires after logging destroyed the regrowing pine forests and were a major impetus in development of fire control organizations. White pine is now regenerating under forest canopies in parts of Wisconsin where seed sources are available on sandy or loamy sand soils. Photo by Paul Pingrey.



Wind is the major natural disturbance factor in northern Wisconsin's hardwood and hardwood-conifer forests. Gap-phase blowdowns like the one shown here are common and are usually small, occupying areas of a tenth-acre or smaller. These disturbances occur frequently, and collectively impact more area than the catastrophic wind events that sometimes accompany tornadoes and severe thunderstorms. Photo by Eunice Padley.